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An assessment of the Gulf of St.Lawrence Herring Stock Complex

by

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Abstract

Landings from the 4T herring stock declined from 270 000 t in 1970 to 40 500 t in 1980. Recently, the fishery has been sustained mainly by the 1974 year-class. The catch matrix shows a decreasing trend in the proportion of mature fish in the catch (6 years old: 91% in 1969, 22% in 1980), while no particularly strong recruitment is obvious since the 1974 year-class entered the fishery. An analysis of the catch rate data reveals that for both the commercial inshore and offshore fishery and groundfish research cruises catch rates are at a historical low, except for the Pictou Island fall gillnet fishery. Total mortality coefficients (Z) were calculated for fully recruited herring, using different fishing effort indices. All the Z values were above 0.94 between 1979-1980, and averaged 1.40. A new partial recruitment vector, which reflected the increasing contribution from young fish, was estimated and used in cohort analysis. The resulting biomass and population number estimates were correlated with different catch rates, with all the coefficients being above 0.92. Estimated fishing mortality of fully recruited fish has increased from 0.290 in 1969 to 1.203 in 1980. A Thompson and Bell yield-per-recruit analysis gave a value of $F_{0.1} = 0.331$.

The stock biomass, age 2 to 11, has declined to 54 500 t in 1980 (weight for the first quarter of the year), 5 percent of the maximum level estimated in 1969.

Résumé

Les captures de hareng du stock 4T ont passé de 270 000 t en 1970 à 40 500 t en 1980. Récemment, la classe d'âge 1974 a contribué le plus fortement à maintenir la pêche. La matrice des prises à l'âge révèle une diminution dans la proportion capturée des poissons matures (6 ans: 91% en 1969, 22% en 1980). D'autre part aucune classe d'âge importante n'est apparente depuis l'avènement de la classe d'âge 1974 dans la pêche.

Les taux de capture commerciaux et de recherche, tant dans la pêche côtière que hauturière, sont à un niveau historiquement faible, sauf en ce qui concerne la pêche automnale au filet maillant à Pictou.

Les taux de mortalité totale (Z) ont été calculés pour les poissons pleinement recrutés, en utilisant divers indices d'effort de pêche. Tous les coefficients de mortalité étaient supérieurs à 0.94 en 1979-1980, avec une moyenne de 1.40.

Le recrutement partiel a été estimé de façon à tenir compte de l'importance grandissante des jeunes individus dans la capture, et utilisé dans une analyse de cohorte. Les estimations de biomasse et d'abondance en nombre de la population ont été corrélées à divers taux de capture. Tous les coefficients de corrélation étaient supérieurs à 0.92. La mortalité par la pêche a ainsi été estimée à 0.290 en 1969 et 1.203 en 1980, pour les poissons pleinement recrutés.

Un taux de mortalité $F_{0\ 1} = 0.331$ a été calculé à l'aide de l'analyse de rendement par recrue de Thompson et Bell. La biomasse pour les poissons de 2 à 11 ans, (pour le premier semestre de l'an) a diminué jusqu'à 54 500 t en 1980, soit cinq pour cent de la biomasse maximale estimée en 1969.

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Commercial landings

Landings of 4T stocks were reported in NAFO division 4T and subdivision 3Pn until 1973, after which date most of the catch was recorded in division 4T (Tables 1, 2 and 3). Total landings (4T, 3Pn) attained maximum (269,721t) and minimum (35,227t) values in 1970 and 1974 respectively. However, since 1973, the total catch has been relatively stable, averaging 43,690t. Quota regulations were set in 1975 but, the catches never reached the TAC level.

In the earlier years (1968 to 1972) landings in subdivision 3Pn represented between 25% and 38% of the total catch. This percentage has dropped to below 1% since 1973.

The purse seines are the gear taking most of the landings, as much as 81% of the total catch in div. 4T, and 97% in subdivision 3Pn, before 1974. The proportion of total landings taken by the offshore fishery has been increasing recently compared to the inshore fishery (Figure 1).

The herring fishery is divided into two main seasons, the spring and the fall, depending on geographical location. In an attempt to study recent trends in the inshore fishery, the whole area between Chaleur Bay and Cape Breton was divided into large areas characterized by similar inshore (gillnet) fishing patterns (Figure 2). The yearly total catch, as well as the proportion from the spring fishery was calculated.

The results (Figures 3, 4, 5, 6 and 7) show a substantial decrease in landings in the Chaleur Bay area (Zone 1), as well as a decline in proportion of catches during the spring fishery, until 1973. Thereafter the relative importance of fishing season fluctuates greatly with years, and the landings are relatively stable despite an apparent increase in fishing effort (Greendale and Powles, 1980). In Zone 2, the landings also declined until 1973, but most of the catch was and is still taken during the spring. Here again an increase in fishing effort was noted between 1971 and 1979 (O'Boyle and Cleary, 1981). In the Pictou and Souris area (Zone 3) the catches from the predominantly fall fishery have increased during the past two years. The 1970 spring fishery appears anomalous. Around Cape Breton Island, Zone 4, the landings also have increased since 1976 following a decline during the period 1967-76 almost all the catches are taken during the spring. In the Magdalen Islands (Zone 5), gillnet catches were not reported until very recently. The reported landings increased significantly in 1979, with a rise in fishing effort (Cleary and Morgan, 1981) and then dropped in 1980, (preliminary catch statistics).

Age composition of the commercial catch

The catch at age data were taken from Winters pers. comm. The original table presented data for spring and fall spawners separately, but these are here combined (Table 4). The age composition matrix of the total commercial catch shows that the 1974 and 1977 year-classes have contributed substantially to the fishery in recent years. The proportion of fish age 6 and older has decreased from 91% in 1969 to 22% in 1980. The mean age of the catch dropped from 9 years (1969) to 4 years (1980). This trend towards decreased age persists until 1980, even with the strong 1974 year-class supporting the fishery from 1977 to 1979. Similar trends in proportion of older fish and mean age have been found for purse seiner and trap catches individually, as was an increase in the number of small fish in the catches (Cleary and Trudeau, 1981; Cleary and Worgan, 1981). This situation could possibly reflect changes in purse seiner fleet activity, fish distribution or in year-class strength. However, a shift in population age structure towards younger age classes may also result from heavy fishing pressure, as in the case of the Pacific sardine (Murphy, 1966). Since the seiner fleet has the capacity to search for schools of herring, and since there is no market for fish smaller than 10 inches, it appears probable that no more larger older fish are available to the fishery, forcing the seiners to catch smaller younger fish.

In the combined (spring and fall spawners) catch-at-age matrix, fish older than 11 years represent up to 38% of the total catch in numbers in a given year. To perform cohort analysis, numbers of 11+ fish were broken down into numbers at older ages. To do so, the following assumption was made: the ratio of number of fish at age 10/the number of fish 10+ in 1969 equals the ratio of fish 11/fish 11+ in 1970, and so on. The numbers prorated in this way were used in the cohort analysis.

Population abundance indices

A number of abundance indices based on catches by research vessels and the commercial fleet were available for the 4T herring stock (Tables 5 and 6; Figures 8 to 11).

In an initial analysis of the purse-seine log books (Figure 8A and Table 5; data from Winters pers. comm.) catch rates (catch/set) remained relatively constant from 1971 to 1975 with subsequent continual decline till 1980. Later the data were re-analysed (M. Sinclair, pers. comm.), and a different pattern of catch-rates versus time was obtained (Figure 8B). All catch-rate indices from the southern Gulf, excluding the "Edge fishery" indicated a sharp decline since 1977 (Figures 8B and 9; Table 6).

Catch rates from the "edge" fishery have not shown a parallel decline, although there was a decrease in 1980 (Table 6 and Figure 9). However this fishery does not exploit a stationary herring population, but schools which are migrating from overwintering to spawning areas. Besides it has been shown (Valdron and Sinclair, pers. comm.) that the seiner fleet has recently changed its area of fishing (since 1977) during the "edge" fishery. Consequently catch-rates from this fishery may not reflect the overall abundance of the stock.

In general, it should be mentioned that purse seiners fish as a fleet; they have searching powers which have improved with time (i.e. introduction of a new sonar in 1976 (McKone pers. comm.)), as well as learning capacity to locate the fish. The validity of seiner catch rates as representative of the fish population abundance has often been discussed, (Powles, 1981; Pope, 1978; Ulltang, 1978) and the facts mentioned above suggest that the catch rates may not reflect the population abundance.

The Southern Gulf groundfish research survey is designed to catch groundfish. Any catch of herring is thus incidental, and catch rates should be accepted with caution. However, there is a general declining trend in herring catch rates since 1970 (Figure 10), giving one some confidence in the results obtained. If the survey was not adequate for herring one would expect that incidental catch of herring would produce fluctuating catch rates with time rather than a series with a trend. In 1980, the research vessel herring abundance index was at its lowest value for since the preceding decade.

Several catch rate series are available from the commercial gillnet fishery. In general all catch rates series are declining and reach their lowest values in 1979 and 1980 (Table 5 and Figure 11). There has been a gradual increase in gillnet fishing effort during the last ten years (Greendale and Powles, 1980; O'Boyle and Cleary, 1981; Cleary and Worgan, 1981; Messieh, 1981). All catch rates, except for the Magdalen Islands gillnets fishery which uses only anchored gillnets, are biased upward because they do not take into account the searching power and learning capacity of that proportion of the boats using drift gillnets. Also the catch rate from the Southern Gulf which is measured in catch per successful trip is thought to underestimate the fishing effort (Messieh, 1981). In sum, one would expect a bias in the gillnet catch rate indices such that they may underestimate recent population declines.

The Magdalen Islands trap catch rates are probably the most reliable abundance estimates presented here since the fishing effort distribution of this fixed gear has been very stable over time: traps have remained in the same emplacements without being moved to concentrate on areas (e.g. spawning beds) where fish are abundant (Cleary and Worgan, 1981). However only spring spawning herring are available to this fishery, and thus the catch rates may not reflect the overall abundance of the stock. The catch rate series shows the abundance of the fish available to be at a historical low in 1980 (Table 5 and Figure 11).

In summary, no abundance index seems to represent accurately the abundance of the whole 4T herring stock. But despite the biases, most of the catch rate series presented show a decline over the last ten years, and the lowest level in 1980.

Correlations between the various catch rate series are shown in Figure 12. Of all the indices, the autumn purse seiner data were highly intercorrelated whatever the units of effort used. Thus, the declining trend of the autumn purse seiner catch rates is independent of the unit of effort used. A high correlation coefficient was also found for the two gillnet catch rates (I and G) from the Southern Gulf. The gillnet catch rate (I) and the purse seiner catch rate (C) from the Southern Gulf also correlate well (r=0.926), but it should be noticed that both of these indices are thought to the biased upward.

Mortality rates

An estimate of 0.2 for the instantaneous natural mortality rate (M) was assumed throughout the present analysis. The possibility of fluctuations with time in the natural mortality rate cannot be excluded, but since no accurate calculations of such a change could be done, M was assumed constant.

Total mortality coefficients (Z) were calculated (Table 7) according to the Paloheimo linear formula (1961), using the catch at age from Winters pers. comm. and the effort values calculated from the following catch rate indices:

a) the research vessel CPUE
b) the Southern Gulf purse seiner CPUE
c) the Southern Gulf gillnets CPUE
d) the Magdalen Islands gillnets CPUE
e) the Magdalen Islands traps CPUE

The average Z values for fully recruited fish were calculated, from 1969 to 1980. The mortality rate between 1979-1980 was always the highest or close to the highest rate since 1969, whatever catch rate was used in the calculation. The average Z for the 1979-1980 period was 1.4.

Partial recruitment

A partial recruitment vector derived from initial runs of cohort analysis proved to be dome shaped. In their most recent analysis Winters pers. comm.), with different calculations and assumptions,also came to the conclusion that the partial recruitment vector was dome shaped. However, it was felt that

the historical partial recruitment values were inappropriate, due to the fact that small fish have predominated the catch only in recent years. Since no appropriate values for partial recruitment were found, a new vector was derived by combining the results obtained by Winters pers. comm. and that from initial runs of a cohort analysis:

Age	2	3	4	5	6	7	8	9	10	11
PR	.19	.65	.9	1.0	.98	.9	.85	.8	.75	.7

This vector was used to run the cohort analysis.

Yield per recruit

A Thompson and Bell yield per recruit relationship was calculated using the above partial recruitment values, and the weight at age, averaged for the spring and fall spawners (weighted on catch numbers), from Winters pers. comm.. The $F_{0.1}$ value was 0.331 and $F_{max} = 0.748$.

Cohort analysis

Cohort analysis was run using the above partial recruitment values until an average weighted F=1.2 (age 6 to 10, weighted on population numbers) was found. This value was obtained by subtracting the natural mortality rate of 0.2 from the average total mortality rate (1.4) calculated earlier from the various catch rate series for 1979-1980. The resulting population number estimates and fishing mortality rates are shown in Table 8. The weighted average F increased from 0.290 in 1969 to 1.203 in 1980.

The population numbers and biomass estimated thus obtained were correlated with:

a) the research vessel catch rate in no/tow (W3 estimator) (Figure 13);
b) the southern gulf gillnet catch rate in t/net-days (Figure 14), and
c) the purse seiners catch rate in c/set (Figure 15).

All the coefficients of correlation were above 0.92.

Changes in biomass

Herring weights at age for the first quarter of the year (Winters pers. comm.) were used to calculate a long term series of comparable biomass estimates from 1969 to 1980 (Table 9). From these estimates, an alarming situation can be seen where the biomass for ages 2 to 11 is estimated to have dropped by 20 fold between 1969 (1 129 700 t) and 1980 (54 600 t), while mature biomass (age 5 to 11) dropped by more than 40-fold during the same period.

Conclusion

The 4T herring stock situation appears to be critical. In spite of high market value for adult herring, TAC levels, although fixed at 50% of $F_{0.1}$ have not been reached. Increased inshore effort (Greendale and Powles, 1980; Cleary and Worgan, 1981; Messieh, 1981; O'Boyle and Cleary, 1981) has not resulted in an appreciable increase of the overall landings. Despite difficulties in interpretation of catch rates, all are at historical lows. The proportion in number of mature fish in the catch dropped more than 4 fold between 1969 and 1980, and the mature biomass is expected to decline further. Furthermore, experimental fishing in the edge fishery area from the 25th to the 30th of April 1981 (A. Sinclair, pers. comm.) yielded no herring. Whatever the reasons for the decline of the stock, it appears from comparison with herring stocks in the eastern Atlantic (Jakobsson, 1980; Dragesund et al. 1980; Saville and Bailey, 1980) that the 4T herring spawning biomass has reached a level where recruitment could be affected.

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Table 1: Herring Landings[a] (t.) from NAFO division 4T, 1967 to 1980.

Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
1967	1742	-	-	409	25220	8764	5679	10718	4620	1358	3095	1131	62736
1968	546	442	806	6455	24239	2566	15847	19768	22350	5284	13057	770	112130
1969	-	-	73	9329	17701	6568	35476	46987	22448	4169	11543	121	154415
1970	-	55	-	21211	15782	2545	51002	36860	24959	18506	3831	746	175497
1971	-	-	42	10644	11895	4809	41521	23067	36282	5163	1053	370	134846
1972	-	-	-	400	6102	2583	11034	9092	14453	7777	2108	41	53590
1973	-	-	-	1876	12801	4221	2135	7737	9436	2079	69	3	40357
1974	-	-	-	1302	14474	1190	2958	3143	7282	3081	1714	9	35153
1975	-	-	-	4028	20229	1428	289	2398	4646	8986	2256	305	44565
1976	-	-	-	8461	14406	961	193	1082	1807	5244	6973	326	39453
1977	-	-	-	7625	8338	8850	244	2125	1148	7166	8726	602	44824
1978	240	-	-	2046	13363	883	526	2487	10095	13672	6981	2848	53141
1979	-	-	-	14681	6588	1324	910	1799	5935	5467	8727	2312	47743
1980[b]	80	-	15	10516	9213	1045	898	2183	1962	9006	5043	540	40501

a From ICNAF statistical bulletin no 17 to 28
b Provisional

Table 2: Herring Landings[a] (t.) from NAFO subdivision 3Pn, 1967 to 1980.

Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
1967	24	69	8	-	28	21	1	27	26	7	4	44	259
1968	712	9152	20696	3253	22	10	7	31	-	21	190	1902	35996
1969	26507	25581	19934	8352	354	2	27	2	224	43	1017	13416	95459
1970	32179	26491	28806	3457	4	4	1	2	-	-	585	2695	94224
1971	21835	23563	19192	3711	1	1	2	-	2	7	26	1572	69912
1972	8327	1053	424	3136	5061	-	1	3	1	2	661	324	18993
1973	222	103	4	40	1	2	3	5	4	6	3	2	395
1974	-	-	-	2	3	2	3	37	21	5	1	-	74
1975	-	-	-	3	5	2	3	2	4	5	-	-	24
1976	-	-	-	4	3	3	1	2	1	1	-	-	15
1977	-	-	-	1	2	3	1	2	2	1	64	-	76
1978	-	1	-	2	1	-	-	-	-	-	-	-	4
1979	-	2	-	4	2	-	-	-	-	-	-	-	8
1980[bc]	-	-	-	-	-	-	-	-	-	-	-	-	-

a From ICNAF statistical bulletin no 17 to 28
b Provisional
c Monthly distribution not available

Table 3: Herring Landings[a] (t.) from NAFO division 4T and subdivision 3Pn, 1967 to 1980.

Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
1967	1766	69	8	409	25248	8785	5680	10745	4646	1365	3099	1175	62995
1968	1258	9594	21502	9708	24261	2576	15854	19799	22350	5305	13247	2672	148126
1969	26507	25581	20007	17681	18055	6570	35503	46989	22672	4212	12560	13537	249874
1970	32179	26546	28806	24668	15786	2549	51003	36862	24959	18506	4416	3441	269721
1971	21835	23563	19234	14355	11896	4810	41523	23067	36284	5170	1079	1942	204758
1972	8327	1053	424	3536	11163	2583	11035	9095	14454	7779	2769	365	72583
1973	222	103	4	1916	12802	4223	2138	7742	9440	2085	72	5	40752
1974	-	-	-	1304	14477	1192	2961	3180	7303	3086	1715	9	35227
1975	-	-	-	4031	20234	1430	292	2400	4650	8991	2256	305	44589
1976	-	-	-	8465	14409	964	194	1084	1808	5245	6973	326	39468
1977	-	-	-	7626	8340	8853	245	2127	1150	7167	8790	602	44900
1978	240	1	-	2048	13364	886	526	2487	10095	13672	6981	2848	53145
1979[c]													47751
1980[bc]													40501

a From ICNAF statistical bulletin no 17 to 28
b Provisional
c Monthly distribution not available

Table 4. Removals at age and age composition from 4T herring stock (after Winters pers. comm.)

Age	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Removals at age (10^{-6})												
1	-	-	-	-	-	-	-	-	2.0	1.5	8.1	2.1
2	2.5	2.3	8.1	5.8	7.5	9.4	1.7	17.4	3.5	15.8	24.6	21.6
3	39.1	50.6	99.1	7.3	6.3	13.8	29.0	9.4	63.3	33.9	19.5	70.4
4	38.4	99.7	99.7	44.7	7.8	19.7	23.3	31.2	15.3	95.3	40.3	14.7
5	32.4	42.9	49.2	57.8	55.2	7.8	28.7	12.6	14.4	19.1	60.3	24.9
6	120.4	42.0	69.6	27.1	29.5	30.8	23.8	33.6	7.2	11.1	13.1	22.6
7	144.8	193.0	97.9	33.7	14.5	13.8	23.4	5.0	23.0	4.3	5.3	7.0
8	46.9	138.8	131.1	31.8	21.1	6.9	7.5	3.4	2.7	15.3	3.8	2.5
9	99.1	53.1	73.6	29.6	13.1	11.5	5.5	4.9	8.0	1.8	5.4	1.5
10	249.4	101.1	37.1	17.8	18.4	5.1	9.0	2.4	3.3	4.6	1.4	0.6
11+	355.8	447.9	295.6	83.8	29.6	22.4	27.6	31.3	30.1	16.7	14.8	5.9
Total	1128.8	1171.4	961.0	339.4	203.0	141.2	179.5	151.2	172.8	219.9	196.6	173.8
Age	9	8	8	7	7	6	6	6	6	5	5	4
Age composition (%) by numbers												
1	-	-	-	-	-	-	-	-	1	1	4	1
2	*	*	1	2	4	6	1	12	2	7	12	13
3	3	4	10	2	3	10	16	6	37	15	10	41
4	3	8	10	13	4	14	13	21	9	43	20	9
5	3	4	5	17	27	5	16	8	8	9	31	14
6	11	4	7	8	15	22	13	22	4	5	7	13
7	13	16	10	10	7	10	13	3	13	2	3	4
8	4	12	14	9	10	5	4	2	2	7	2	1
9	9	5	8	9	6	8	3	3	5	1	3	1
10	22	9	4	5	9	4	5	2	2	2	1	*
11+	32	38	31	25	15	16	16	21	17	8	7	3
6+	91	84	74	66	62	65	54	53	43	25	23	22

*less than 1%

Table 5: Abundance indices from research trawl survey and various fisheries exploiting 4T herring stock.

	Research Vessel	Purse Seiners					Gillnets					Traps
	a	b	c	d	e	f	g	h	i	j	k	l
1969		61.0	110.2									
1970	85.16	47.7	90.9							100.0		204.8
1971	96.84	40.3	53.9-56.7**					25.19		100.0		328.8
1972	34.41	25.7	45.1					15.86		57.7		123.3
1973	37.82	35.2	45.1				2.17	19.29	96.36	57.7		90.9
1974	4.73	34.1	37.9	33.2	47.6	23.7	1.65	11.32	92.21	46.4		80.2
1975	33.12	54.2	34.5	40.6	52.7	30.3	2.12	8.47	83.34	45.9		59.0
1976	14.78	45.8	40.6	76.1	84.4	41.5	1.98	9.14	89.41	56.1	15	40.3
1977	15.24	35.3	44.4	77.4	95.3	41.4	2.61	6.21	124.82	53.0	9	72.0
1978	82.46	27.3	44.3	70.5	84.4	39.1	2.16	10.06	89.28	52.1	12	33.6
1979	13.06	48.5	24.5	24.1	37.4	22.0	1.51	8.06	50.67	60.4	33	7.3
1980	2.90*	34.4	18.7	29.9	45.2	20.1	1.00		33.51	47.7	21	2.1

* preliminary
** 53.9 from Winters and Moores, 1980; 56.7 from Winters pers. comm.
a no/set, estimator W3 (Randall and Stobo., 1981)
b catch/set, Edge fishery (Winters pers. comm.)
c catch/set, southern gulf fishery (Winters and Moores, 1980; Winters pers. comm.)
d catch/night, (M. Sinclair, pers. comm.)
e catch/successful night (M. Sinclair, pers. comm.)
f catch/set, (M. Sinclair, pers. comm.)
g t/successful fishing trip (Messieh, 1981)
h t/net-days, southern gulf (O'Boyle, pers. comm.)
i kg/net, southern gulf (Messieh and O'Boyle, pers. comm.)
j lb/net-days Magdalen Islands (Cleary and Morgan, 1981)
k catch/boat Pictou fall fishery (M. Sinclair, pers. comm.)
l t/trap, Magdalen Islands (Cleary and Morgan, 1981)

Table 6. Abundance indices for the purse seiner "edge" fishery.*

	Catch/night	Catch/succ. night	Catch/set.
1974	99.1	99.1	33.0
1975	111.6	116.1	55.4
1976	90.8	93.2	40.2
1977	61.9	68.8	28.4
1978	51.3	71.6	46.6
1979	93.9	101.8	40.6
1980	76.0	88.6	32.3

* M. Sinclair pers. comm.

Table 7: Total mortality rates (Z)* for 4 T herring calculated with effort index derived from different research and commercial catch rates.

Catch rates	Mortality rate										
	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
Research w/tow	-	-0.287	1.547	0.425	2.092	-1.849	1.979	0.427	-0.643	2.804	1.605
P.S. c/set (Southern Gulf)	0.254	0.536	0.343	0.102	0.773	0.630	0.800	0.270	0.622	1.163	0.980
GN c/net-days (M. I.)	-	0.013	0.714	0.102	0.817	0.547	0.762	0.416	0.637	0.422	0.946
GN c/net-days (Southern Gulf)	-	-	0.627	-0.094	1.132	0.826	0.886	0.746	0.137	0.792	-
GN c/s. trip (Southern Gulf)	-	-	-	-	0.643	0.637	0.892	0.026	0.955	1.137	1.123
TRAPS c/trap (M. I.)	-	-0.461	1.145	0.407	0.724	0.843	1.344	-0.221	1.382	2.097	1.956

* Z calculated for ages 6 - 10 to 7 - 11

Table 8. 4T herring population numbers and fishing mortality rates estimated from cohort analysis.

FISHING MORTALITY

Age	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
2	0.005	0.004	0.061	0.019	0.058	0.057	0.013	0.043	0.021	0.252	0.152	0.243
3	0.106	0.130	0.264	0.071	0.026	0.144	0.251	0.096	0.216	0.293	0.564	0.832
4	0.083	0.427	0.409	0.182	0.101	0.104	0.385	0.470	0.223	0.585	0.682	1.152
5	0.081	0.126	0.387	0.442	0.359	0.140	0.218	0.372	0.413	0.481	0.954	1.280
6	0.161	0.144	0.309	0.383	0.426	0.349	0.818	0.428	0.377	0.655	0.727	1.254
7	0.332	0.418	0.582	0.241	0.364	0.361	0.490	0.393	0.592	0.467	0.776	1.152
8	0.247	0.617	0.563	0.376	0.234	0.295	0.341	0.119	0.382	1.067	0.856	1.088
9	0.308	0.491	0.805	0.234	0.261	0.193	0.406	0.391	0.451	0.476	1.728	1.024
10	0.405	0.598	0.779	0.454	0.223	0.153	0.227	0.311	0.501	0.512	0.867	0.960
11	0.290	0.600	0.772	0.448	0.230	0.154	0.225	0.310	0.493	0.526	0.839	0.896
F 6-10	0.290	0.434	0.548	0.307	0.294	0.283	0.475	0.359	0.499	0.717	0.890	1.203

POPULATION NUMBERS

Age	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
2	561	578	152	342	147	187	141	459	184	79	193	110
3	430	457	471	117	275	114	144	114	360	147	50	136
4	532	317	329	296	89	220	81	92	84	238	90	23
5	458	401	169	179	202	66	162	45	47	55	108	37
6	895	346	289	94	94	116	47	107	25	26	28	34
7	567	624	245	174	53	50	67	17	57	14	11	11
8	237	333	336	112	112	30	29	33	9	26	7	4
9	413	151	147	157	63	73	18	17	24	5	7	3
10	828	248	76	54	102	40	49	10	9	13	3	1
11	639	452	112	28	28	67	28	32	6	5	6	1

Table 9. Southern Gulf herring biomass, for the first quarter of the year, from 1969 to 1980.

Age	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
2	23234	23831	8185	13906	11222	13261	11938	47585	16376	6979	11400	10116
3	39034	44624	47008	9144	32002	16784	19697	19865	55596	20278	6023	17161
4	91498	48750	47607	57315	15676	42183	14676	19171	14802	47259	15294	4071
5	83652	77714	33487	35452	44037	15583	35080	10503	10712	12947	24531	8332
6	185346	74659	41865	23118	23377	31487	12271	27149	6257	7174	7340	8629
7	129987	142679	58173	45284	14337	14358	19650	4685	14811	4162	3125	3340
8	57299	83843	85136	30353	33420	9471	8423	9767	2599	8135	2300	1342
9	107799	39448	39623	45104	19061	16837	5742	5055	7167	1660	2391	873
10	230910	68510	20949	16036	32117	13152	16030	3277	2673	4302	905	386
11	180901	134571	33749	8967	9796	23499	10096	11203	1954	1674	2358	367
2+	1129656	738629	415782	284679	235045	196615	153603	158260	132947	114570	75667	54617
5+	975894	621424	312982	204314	176145	124387	107292	71639	46173	40054	42950	23269

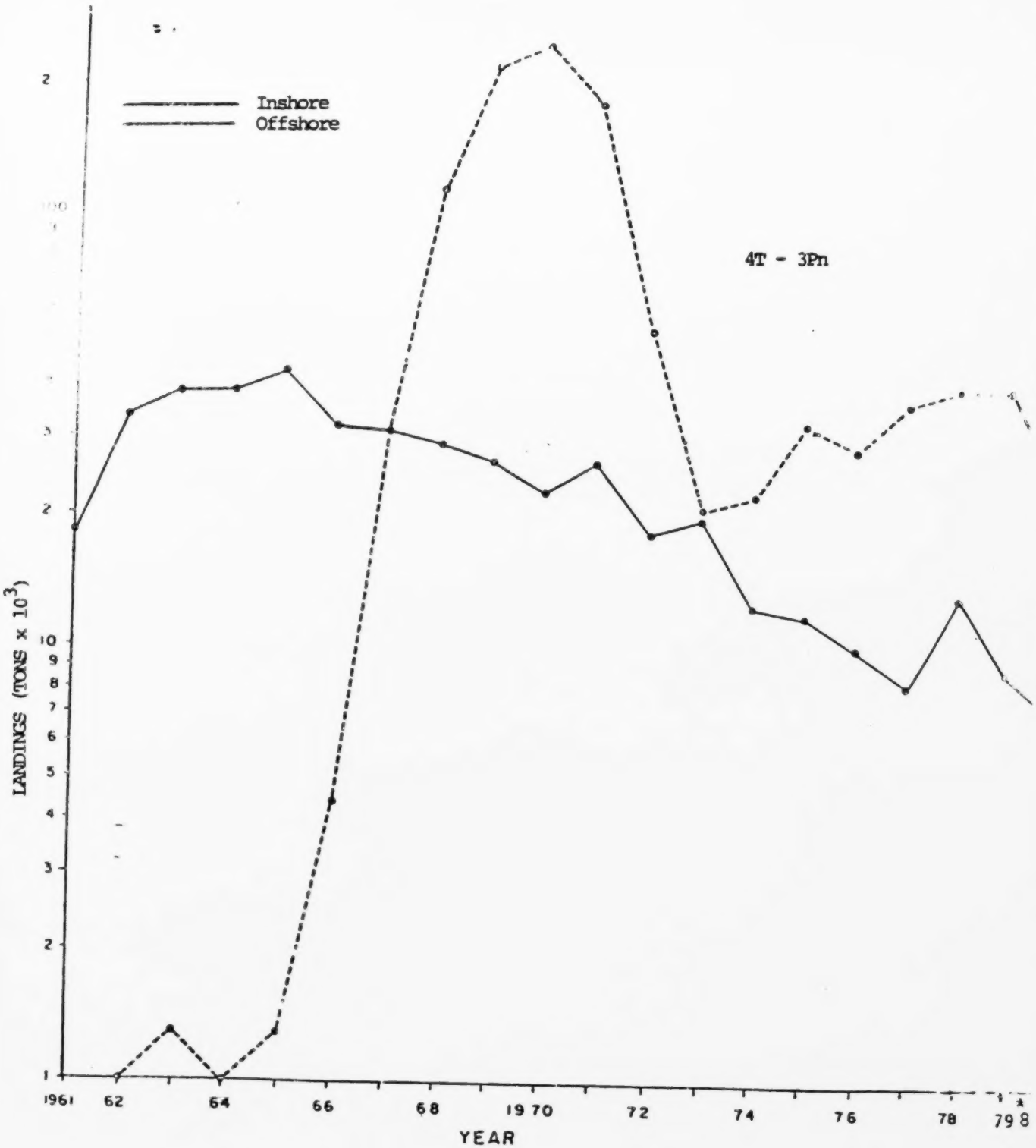


Figure 1 . Commercial landings of 4T-3Pn herring, from the inshore and offshore fishery. (* provisional)

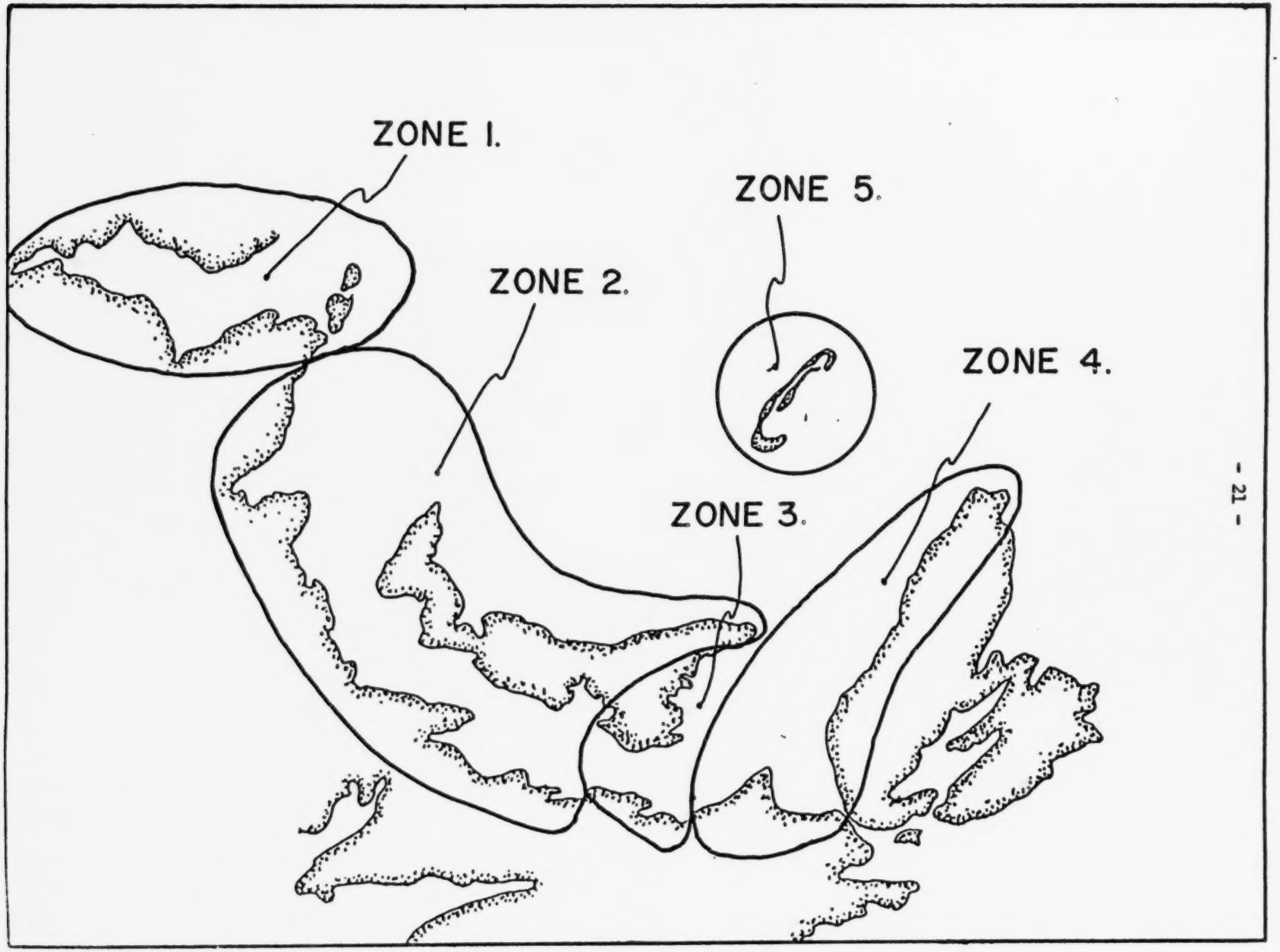


Fig. 2. Geographical zones showing similar herring gillnet fishing seasons patterns.

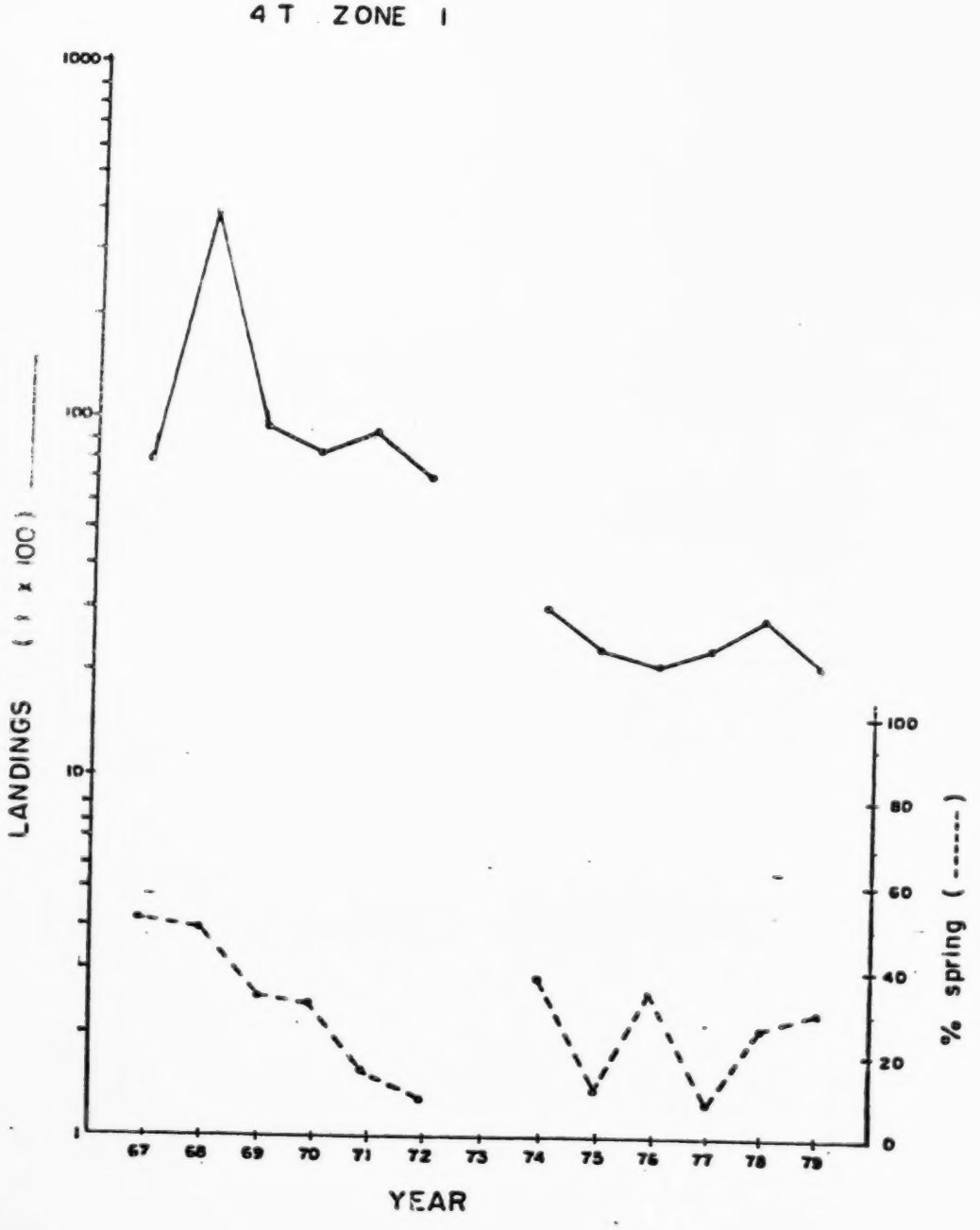


Fig. 3. Total herring landings from gillnets and proportion of the catch taken during the spring season in the Chaleur Bay area (Zone 1). Data for 1973 not available.

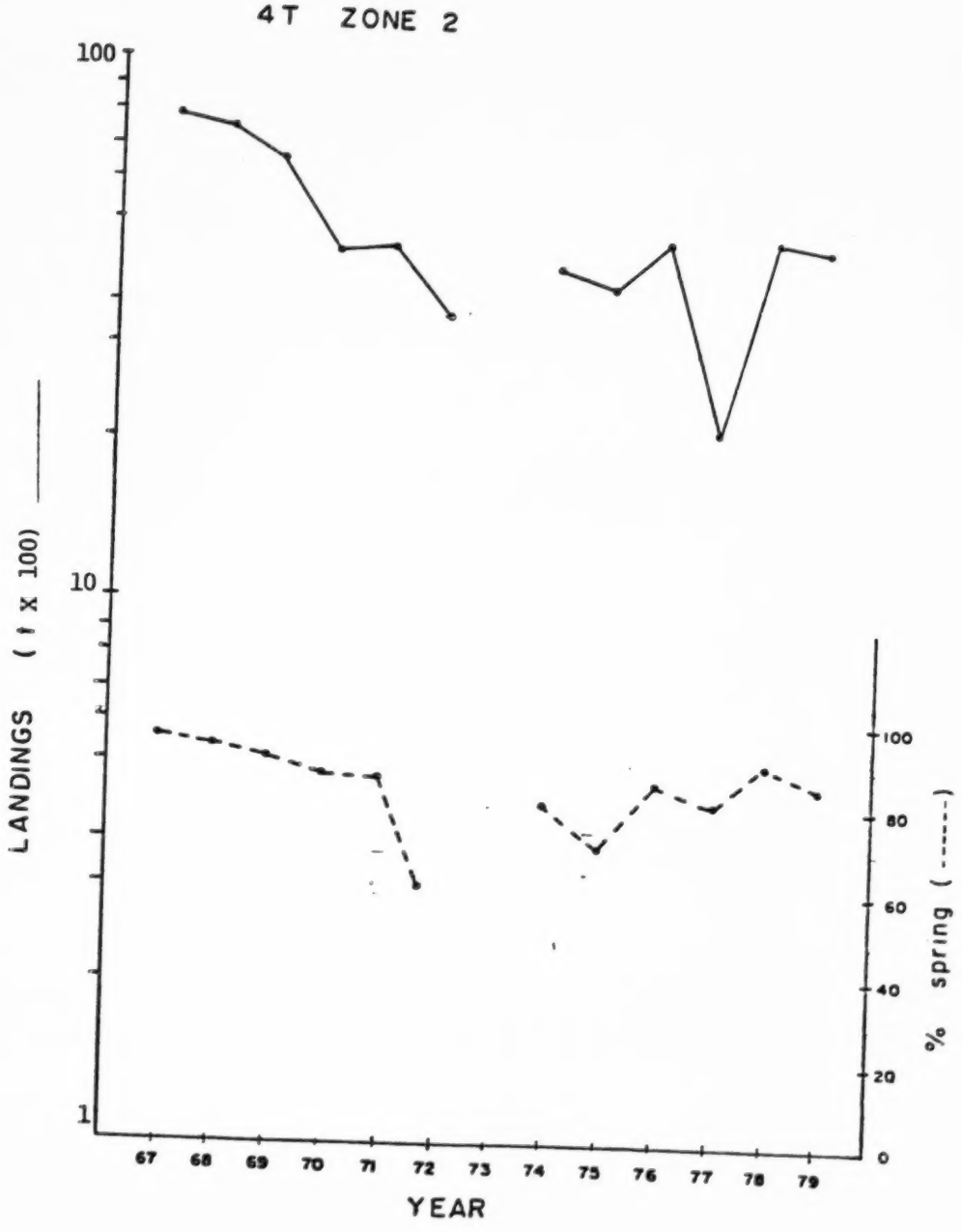


Fig. 4. Total herring landings from gillnets and proportion of the catch taken during the spring season in the Northumberland Strait (Zone 2). Data for 1973 not available.

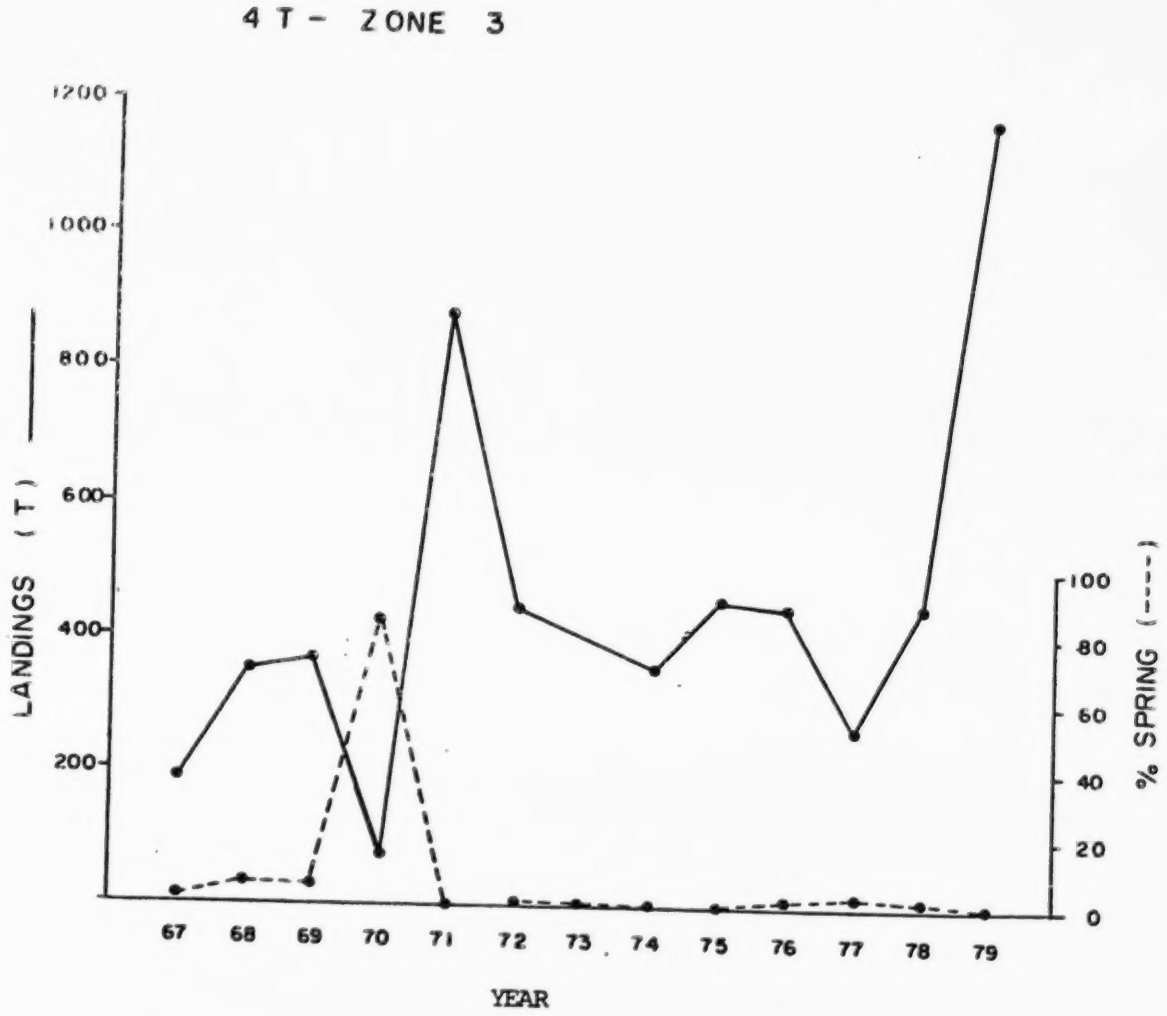


Fig. 5. Total herring landings from gillnets and proportion of the catch taken during the spring season in the Pictou and Souris area (Zone 3). Data for 1973 not available.

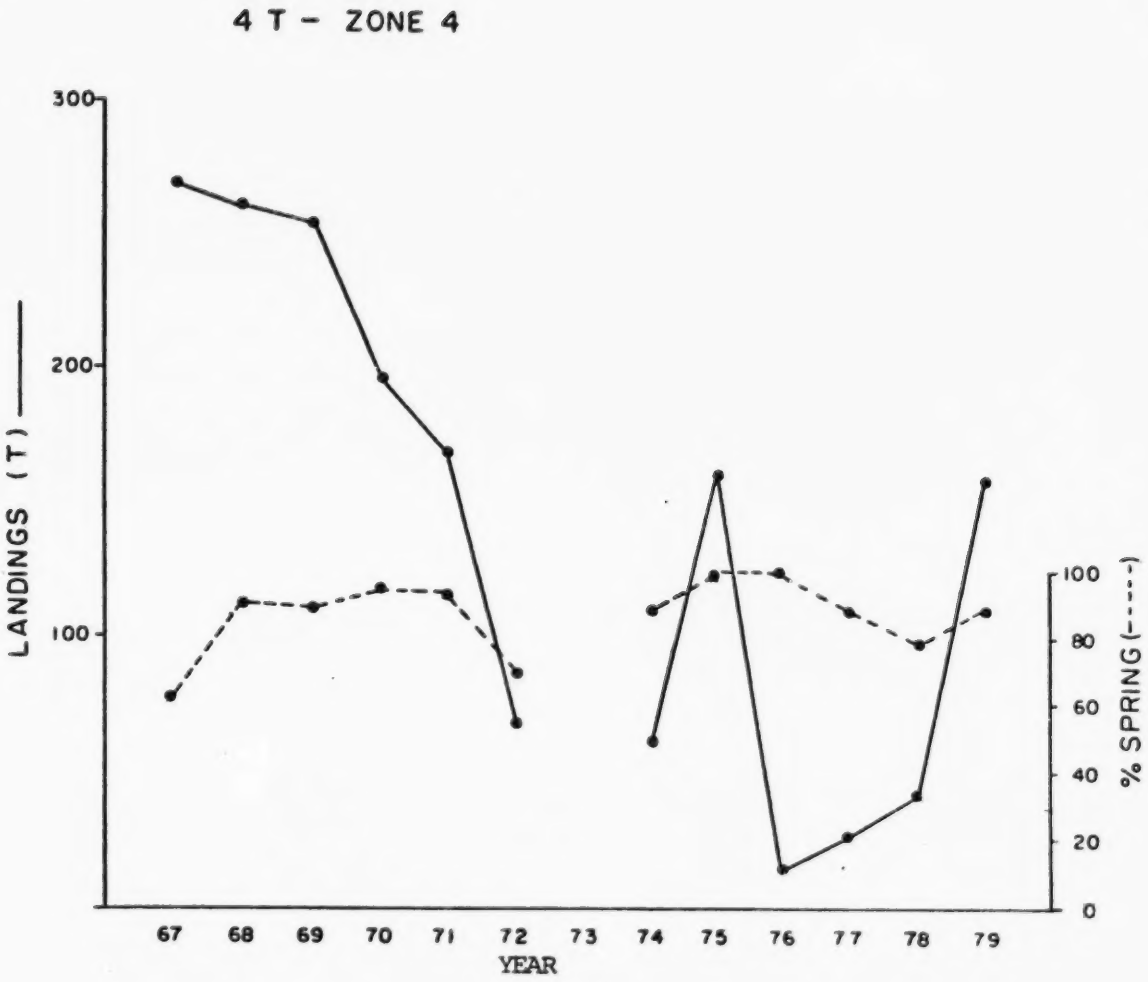


Fig. 6. Total herring landings from gillnets and proportion of the catch taken during the spring season in the Cape Breton area (Zone 4). Data for 1973 not available.

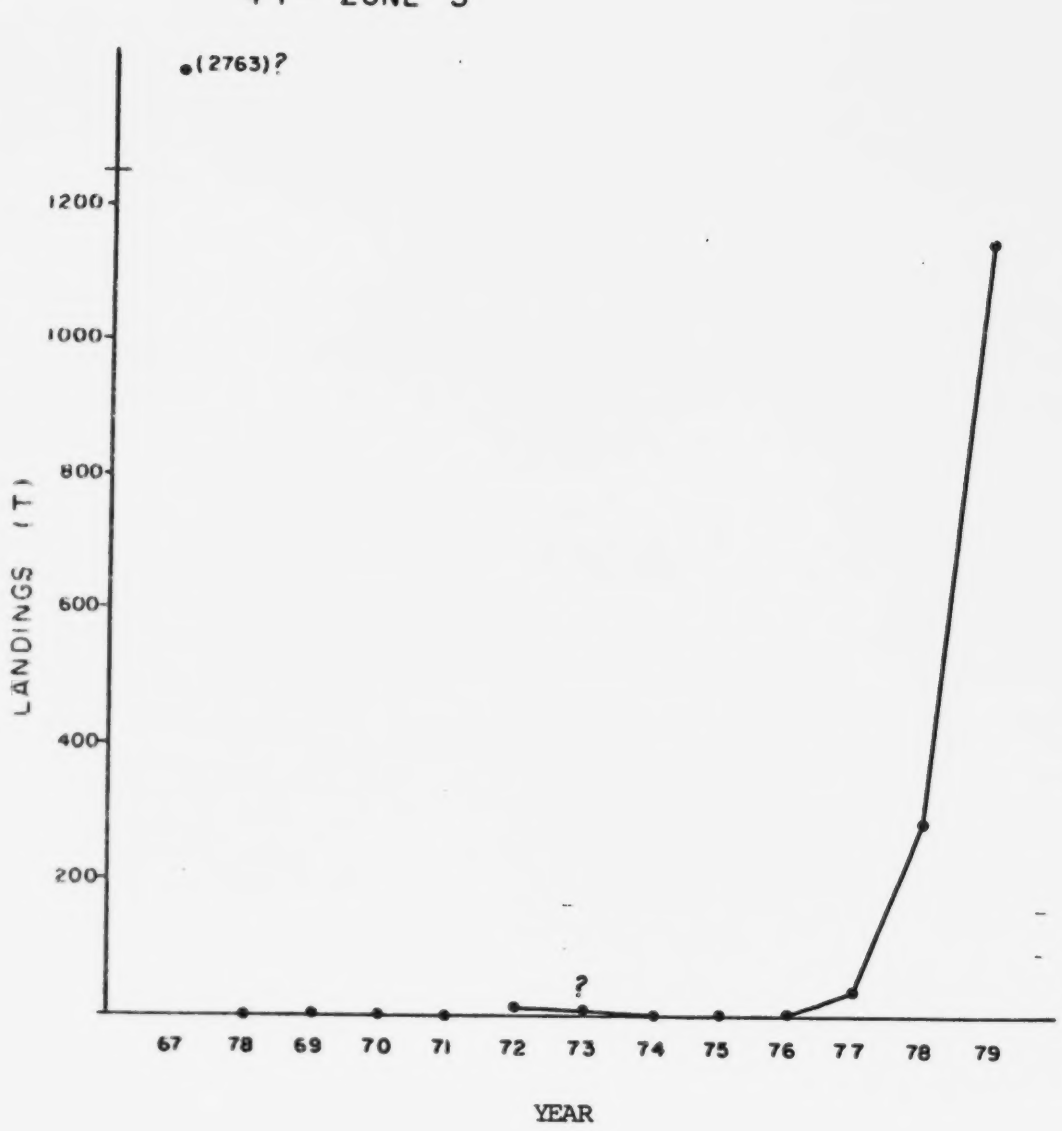
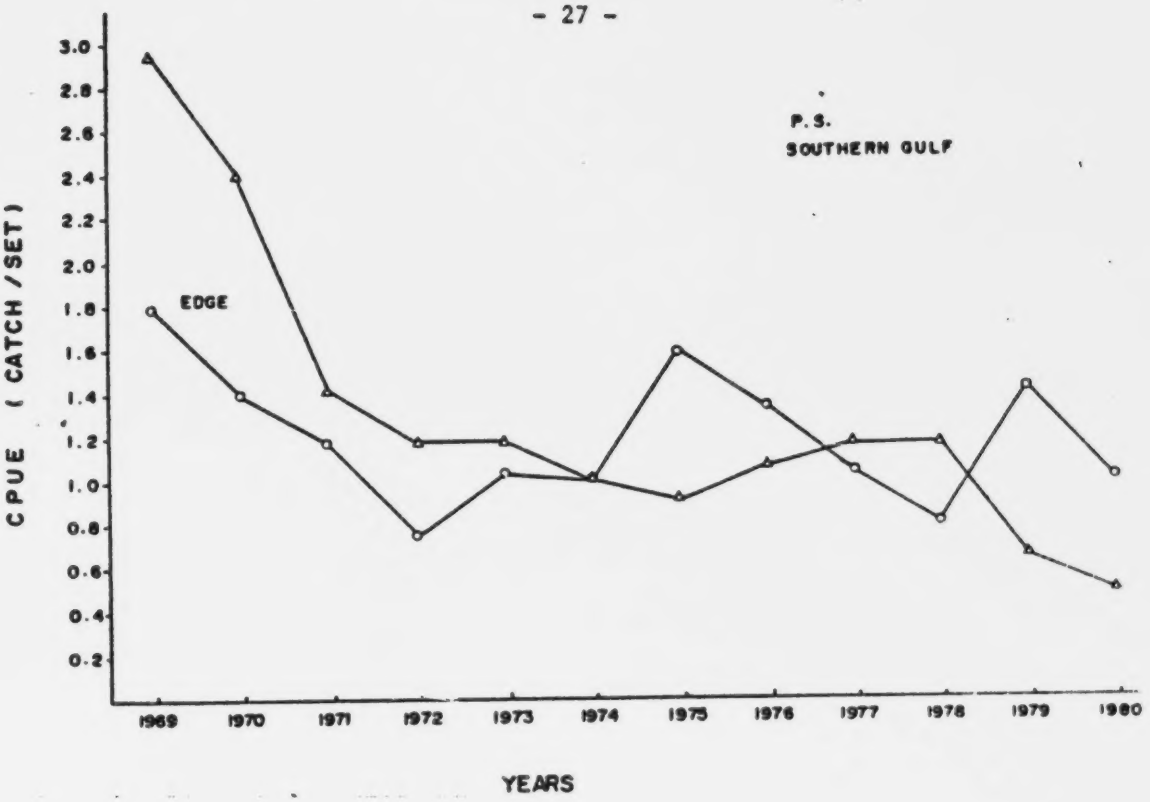


Fig. 7. Total herring landings from gillnets with 100% of the catch taken during the spring season in the Magdalen Islands (Zone 5).

A



B

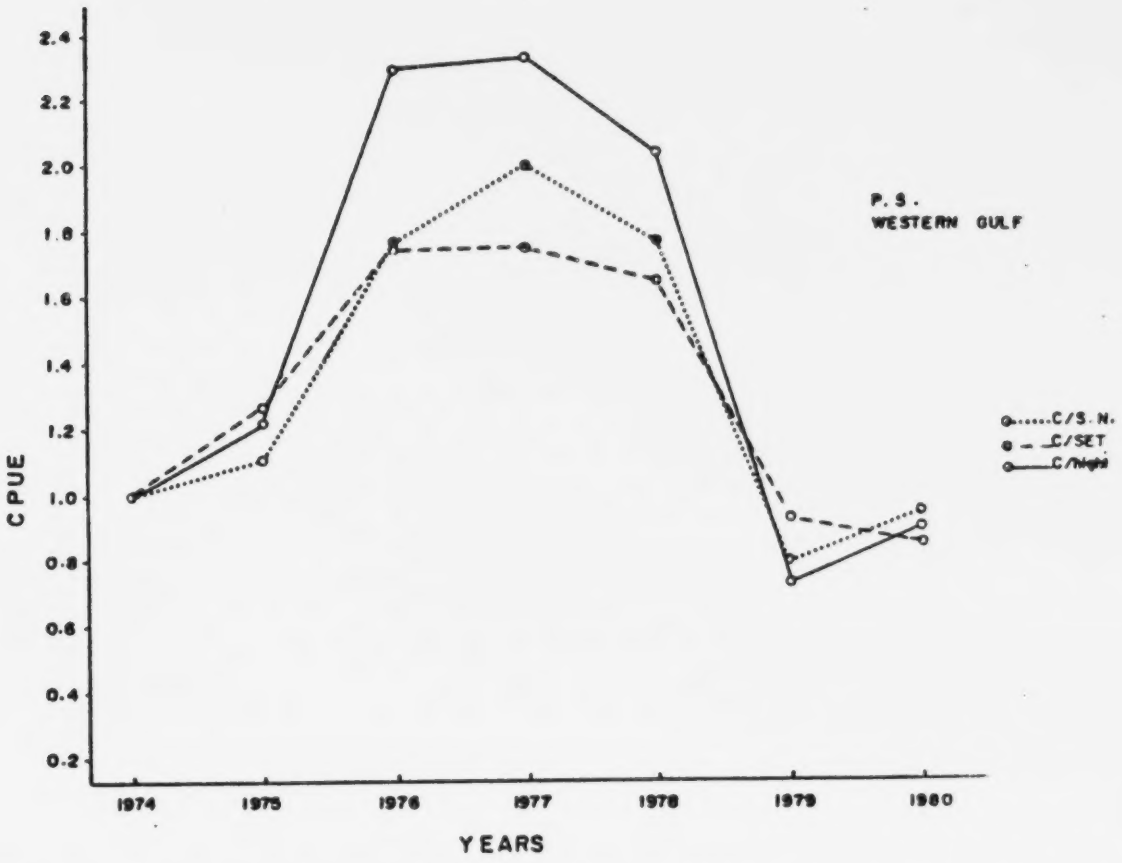


Fig. 8. Herring catch rates from purse seiners fishing A. in the "Edge" and Southern Gulf fishery (after Winters pers. comm.) B. in the Southern Gulf fishery (after M. Sinclair, pers. comm.)

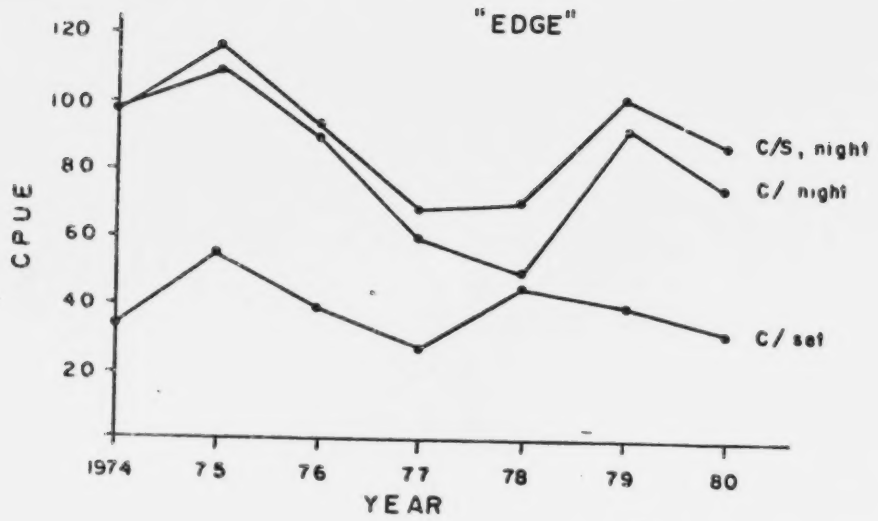


Fig. 9 .Herring catch rates from the purse seine fishery on the "Edge". (M. Sinclair, pers. comm.)

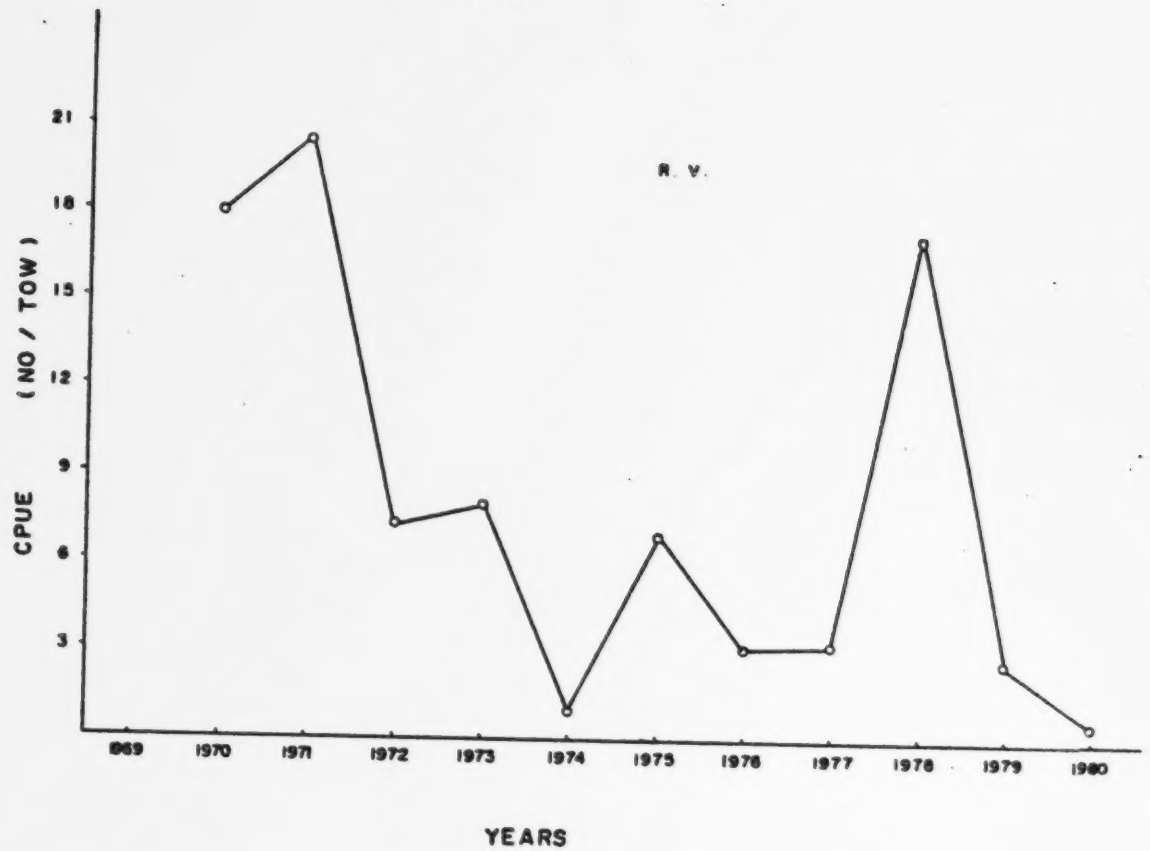
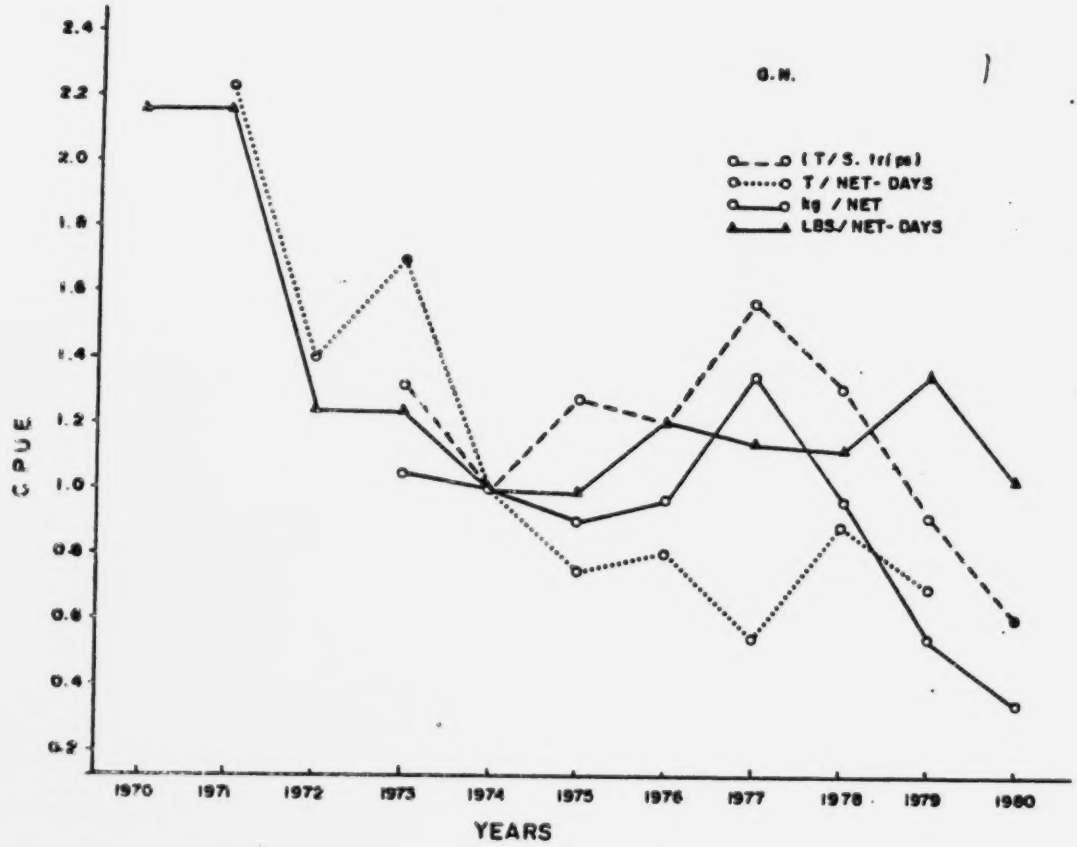


Fig. 10. Herring catch rates from the groundfish research survey (Randall and Stobo, 1981).



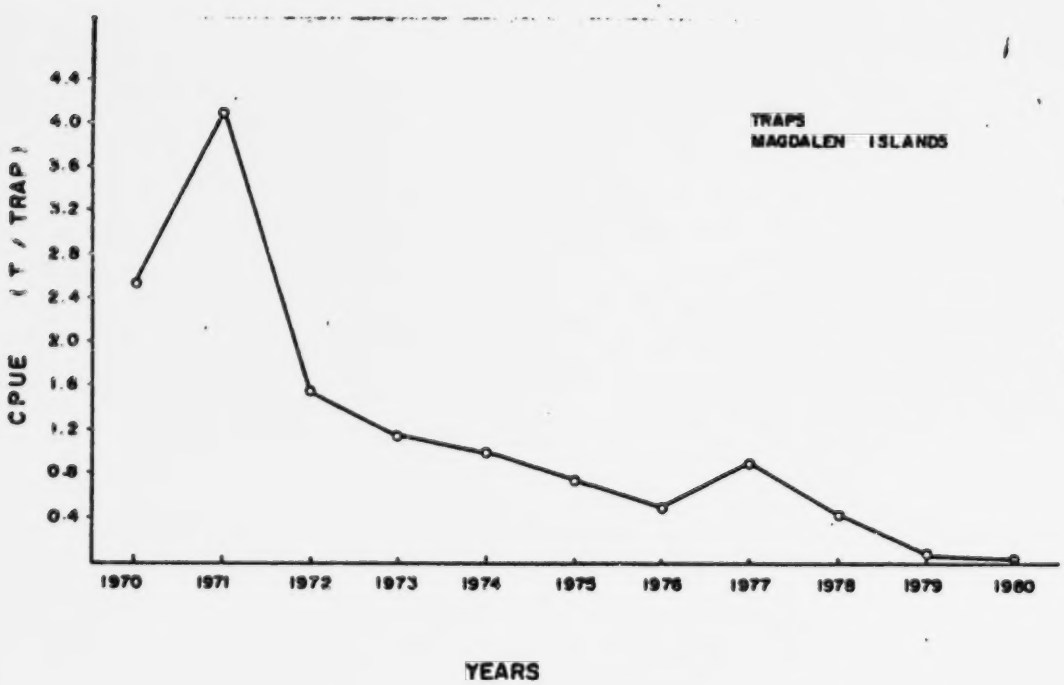


Fig. 11. Herring catch rates from gillnets and traps fishing commercially in the Southern Gulf of St. Lawrence and Magdalen Islands.